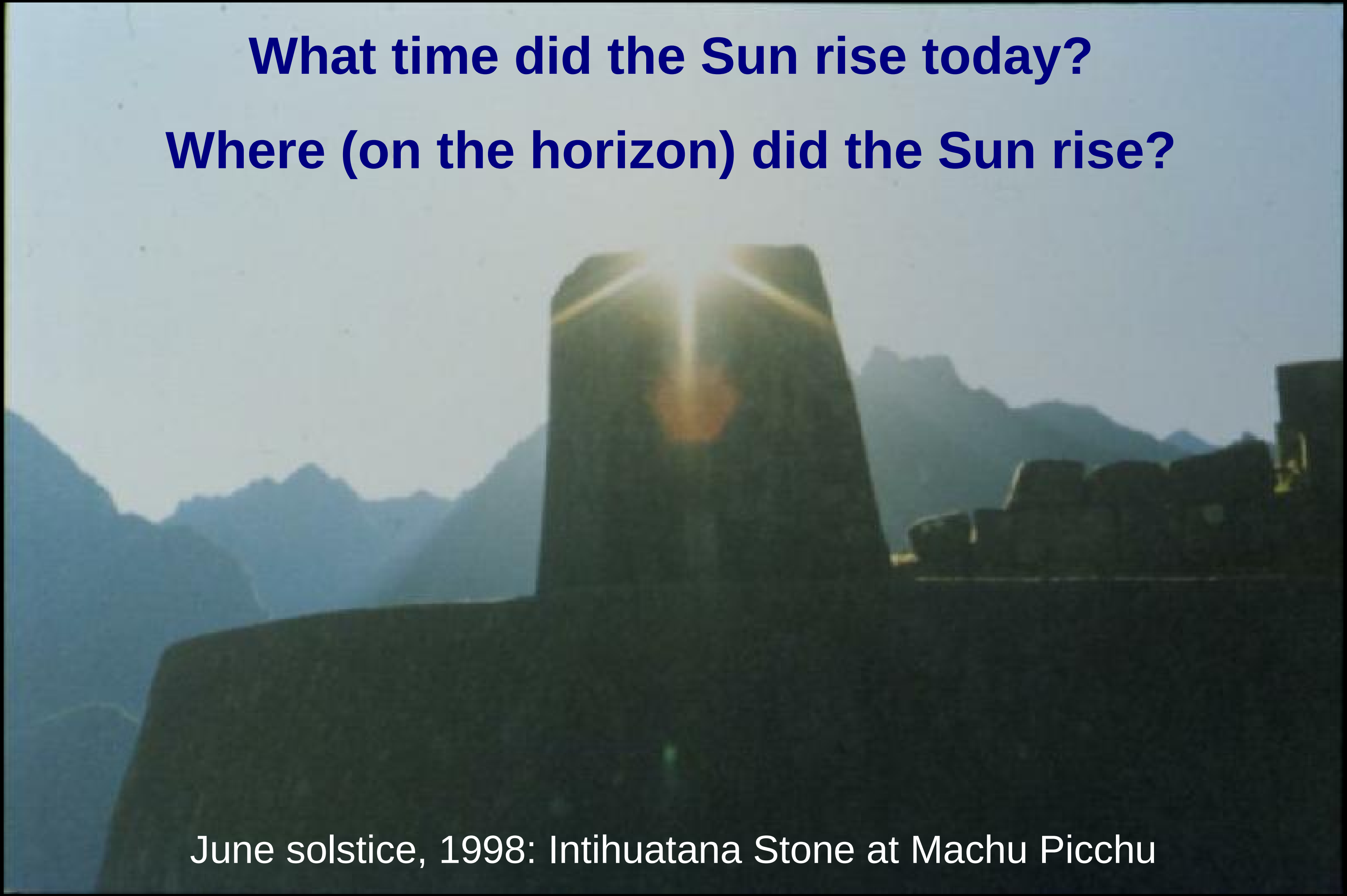
The Sun in Time:
How and Why the Sun Has Affected Cultures



June solstice, 1998: Intihuatana Stone at Machu Picchu

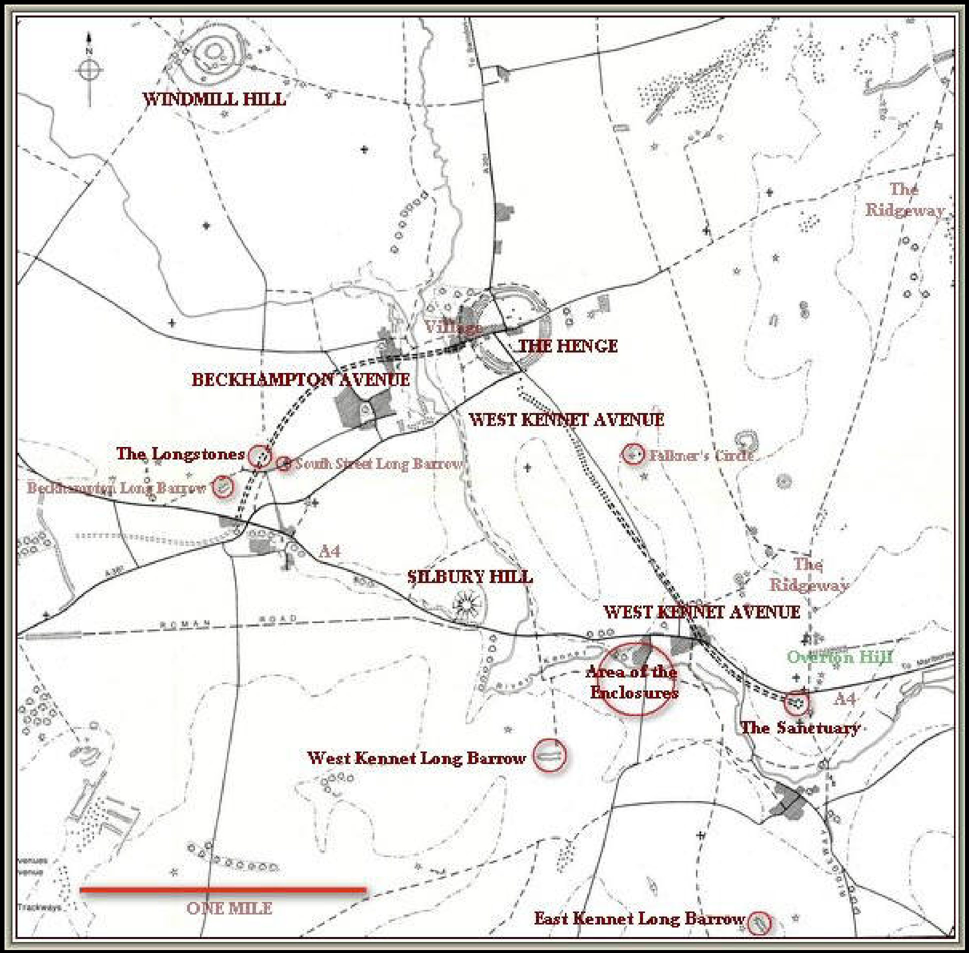
Mitzi Adams, M.S.
Heliophysics and Planetary Group
NASA/MSFC

Observing the Sun in Years Past

Built, Over Many Years, c. 3000 BCE

Observing the Sun in Years Past – Avebury

Age: c. 2850 BCE, modified up to c. 2200 BCE



The area of the circle is about 28.5 acres,
the circumference is approximately 0.8 mi..

The stone circle of Stonehenge would fit into the outer stone circle at Avebury around 130 times.

from http://www.avebury-web.co.uk/

The Human Desire for Understanding

We Observe, and We Measure, and We Mark

Silbury Hill

W. Kennet Longbarrow (c. 4000 - 2400 BCE)

Types of Observations -- the How

Solstice Risings and Settings

Equinox Risings and Settings

Retrograde Motions of Planets

Precession of Equinoxes

Solar / Sidereal Day / Year

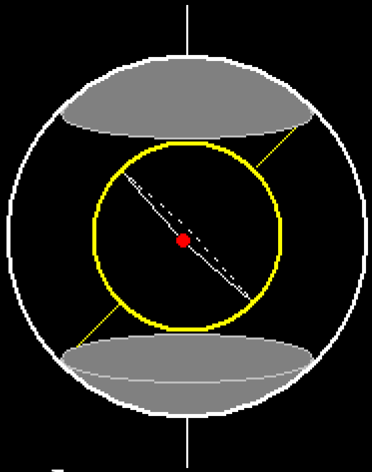
Eclipses

August, 2017 Eclipse Image: Joe Matus, NASA/MSFC, used with permission

The Beginnings of Western Science: Creating Order from Chaos -- the Why

Eudoxos, c. 375 BCE: Nested Sphere Model of the Universe

1. Earth is the center of the universe
2. All celestial motion is circular
3. All celestial motion is regular



4. The center of the path of any celestial motion is the same as the center of its motion
5. The center of all celestial motion is the center of the universe

...led to Ptolemy’s epicycles and deferents (c. 100 - 1200 C.E.).

Meanwhile in Central America
the Maya Observed Planets, Sun, and Moon
c. 900 CE

El Castillo, or
Temple of Kukulkan

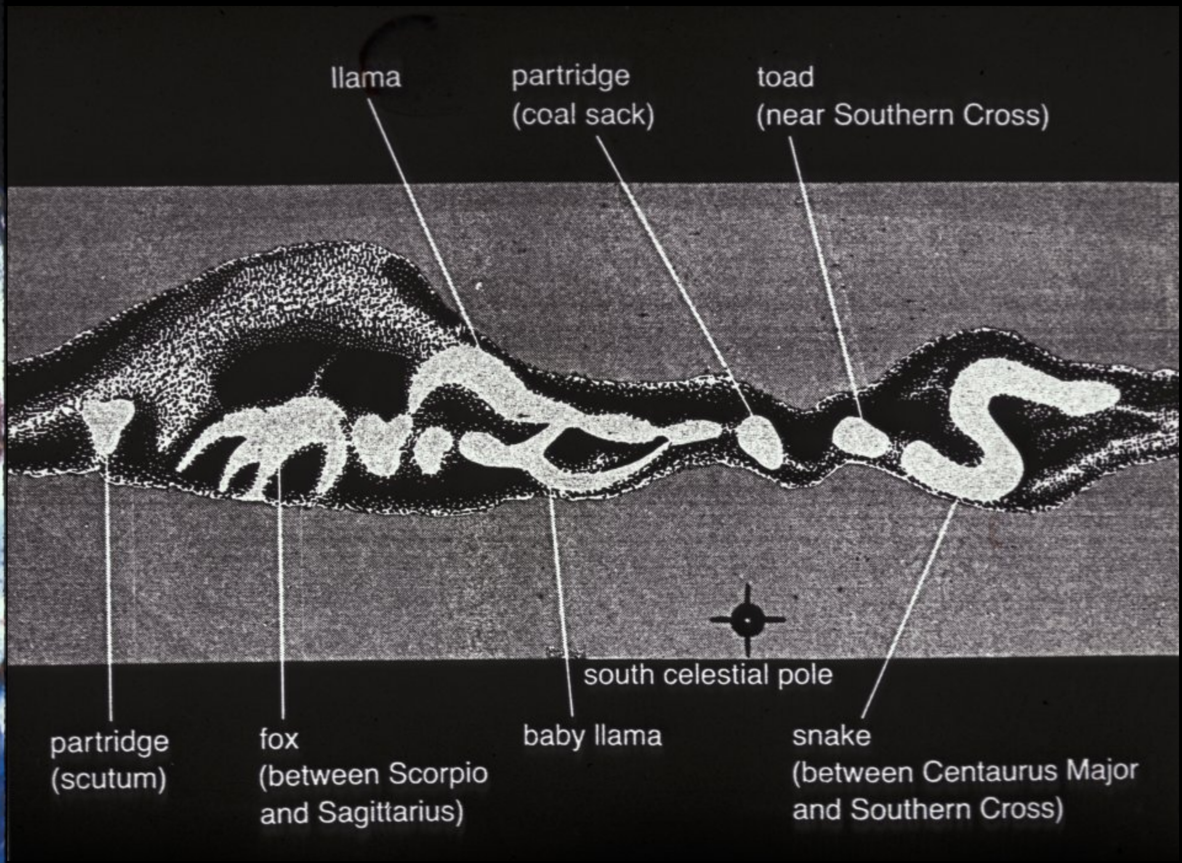
El Caracol, Chichen Itza

Observing the Sun in Peru

Only about 500 - 600 years ago
c. 1500

Maps from:
https://www.cia.gov/library/publications/the-world-factbook/attachments/images/large/south_america-political.jpg?1547145653

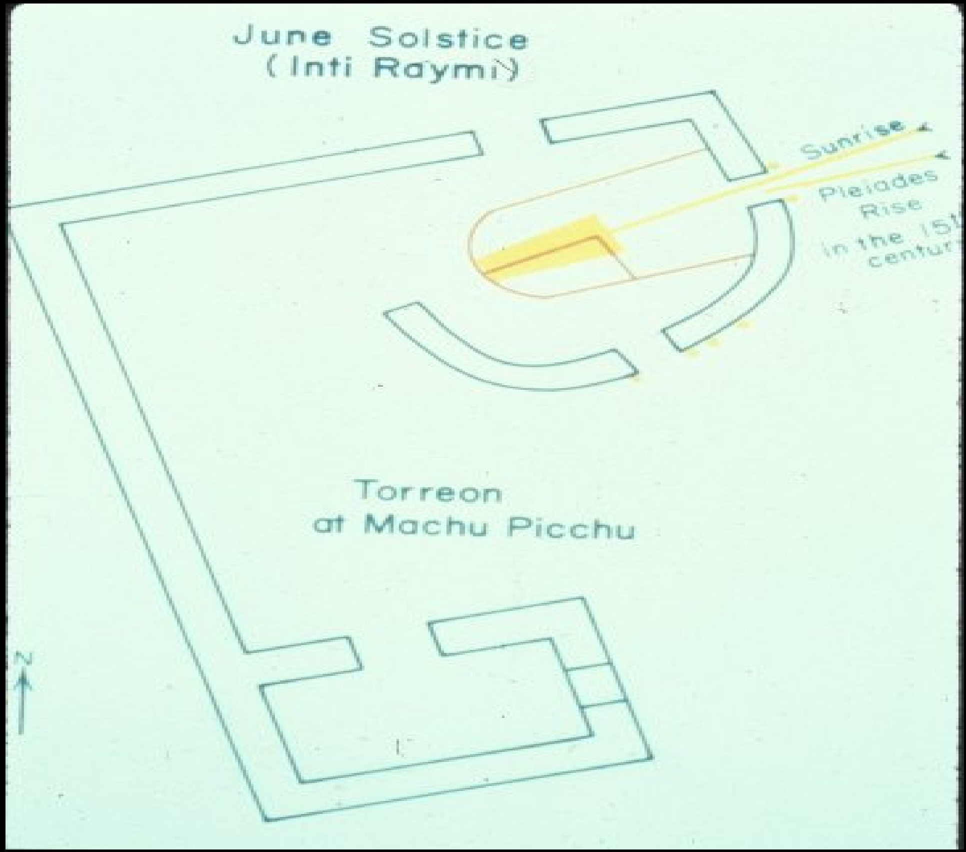
The Inca World View



Cuzco


Chinchero
Autumnal Equinox

Torreon


June Solstice
(Inti Raymi)
Sunrise
Pleiades
Rise
in the
Torreon
at Machu Picchu
N

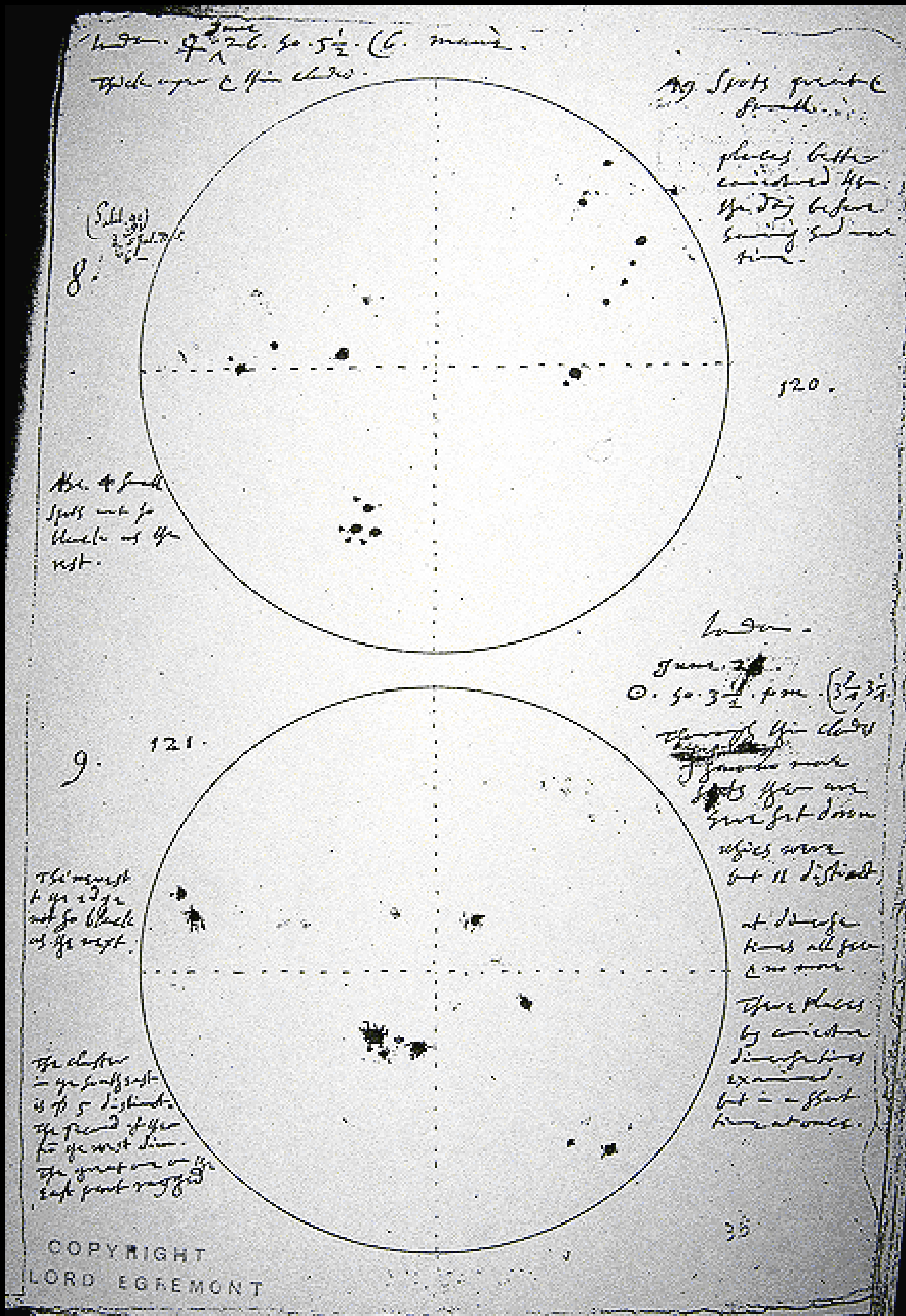
Intihuatana

Down in the Jungle:
Cacao, Cashews

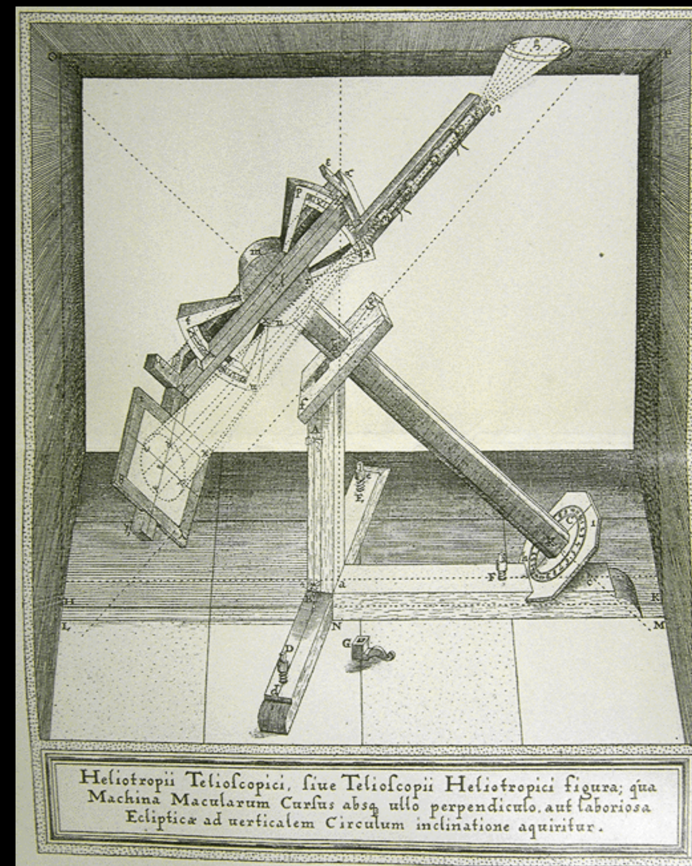
On the Road to Modern Solar Observations

Meanwhile in Europe, c. 1610...

Galileo Galilei, Christoph Scheiner, Thomas Harriot



These three began to use the telescope to study the Sun using a telescope. Scheiner's telescope is below.

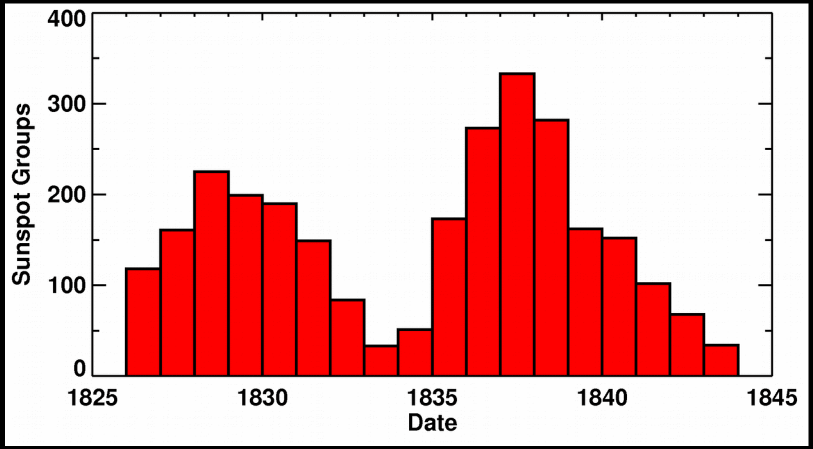


Thomas Harriot's sunspot drawings,
used with the kind permission of Lord Egremont.

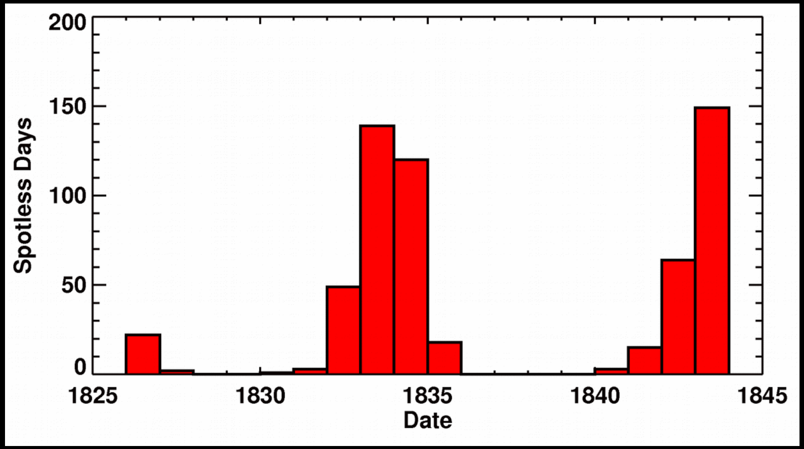
Sunspot Cycle Discovery

~ 230 years after Galileo, Heinrich Schwabe, an amateur astronomer in Dessau, Germany, discovered that the number of sunspot groups and the number of days without sunspots increased and decreased in cycles of about 10-years.

Schwabe's data for 1826 to 1843



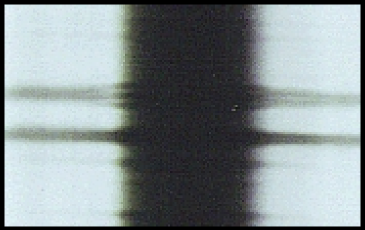
Number of Sunspot Groups per Year

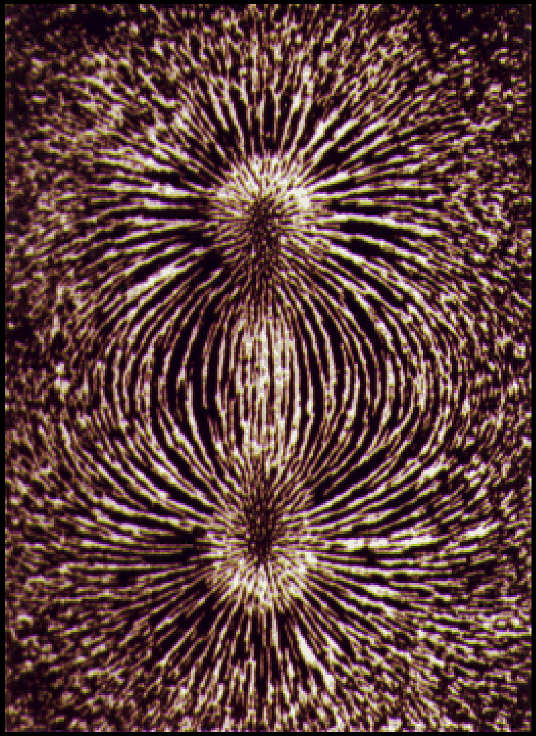


Number of Spotless Days

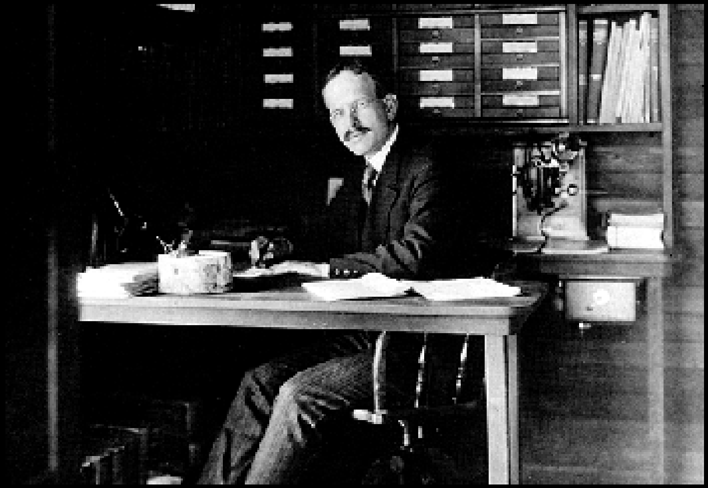
Measuring Magnetic Fields

Fraunhofer, early 1800s



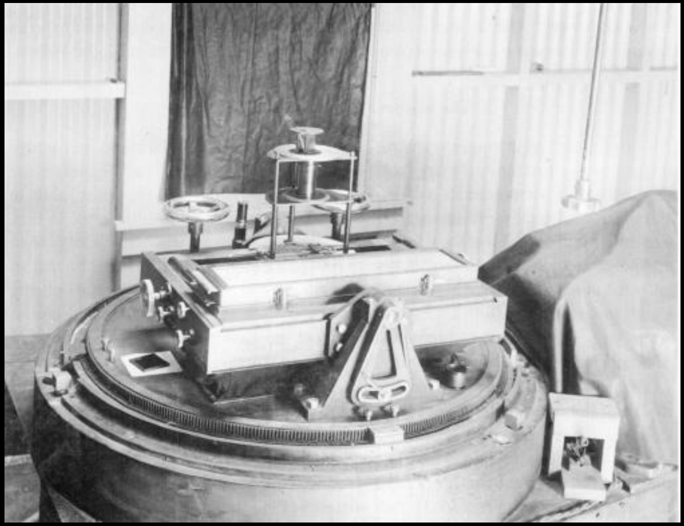


Zeeman, 1886

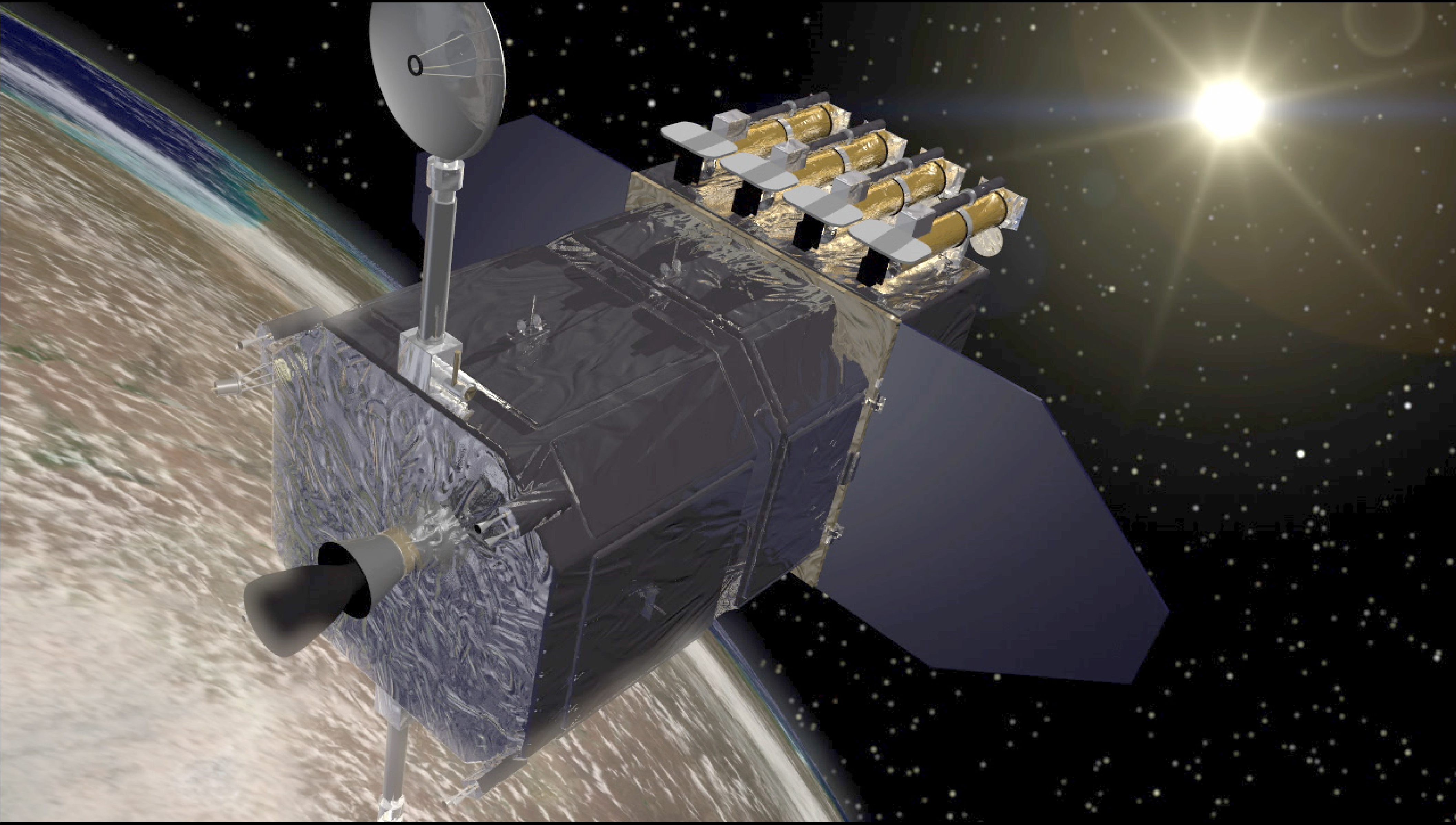


George Ellery Hale, early 1900s

30 ft spectrograph at 60 ft telescope,
Solar Physics, vol. 100, 1985.
1985SoPh..100..171H

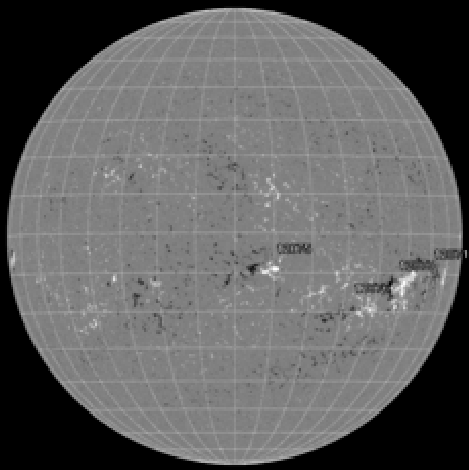


Observing the Sun Today

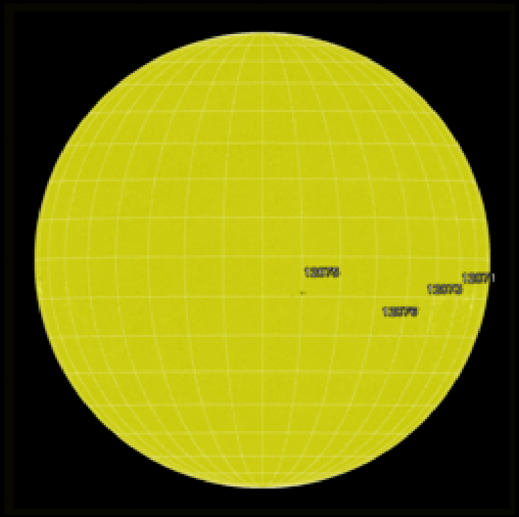


The Solar Dynamics Observatory

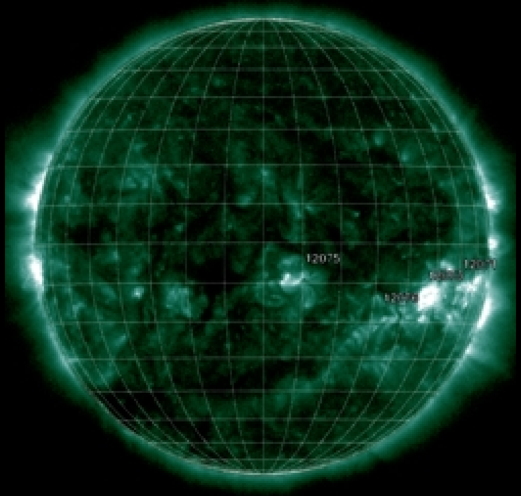
SDO Wavelength Samples
May 30, 2014



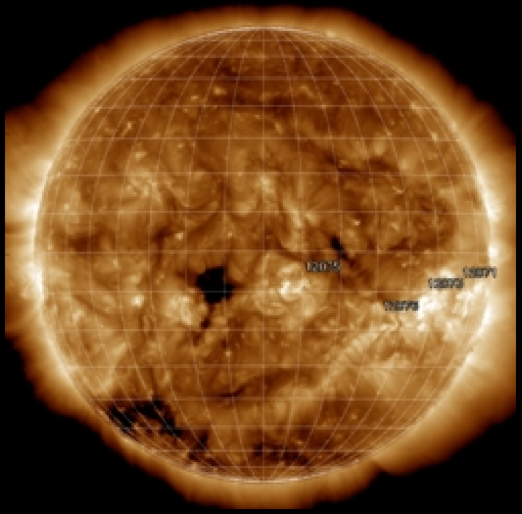
HMI



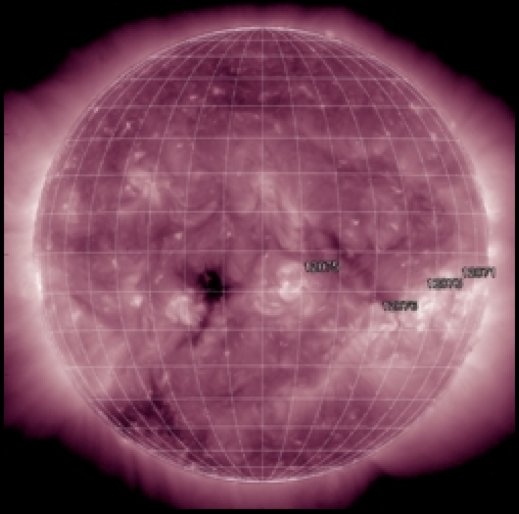
HMI - 6173 Å



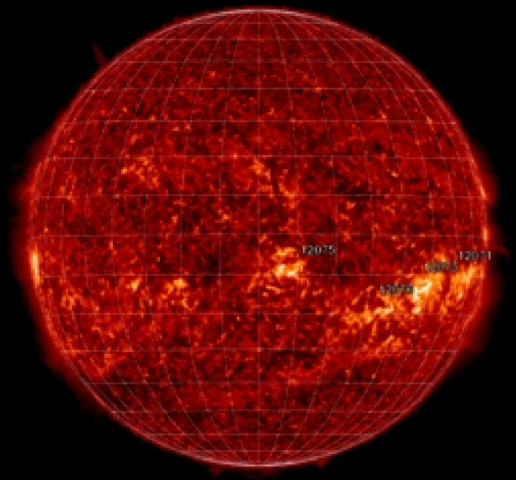
AIA - 94 Å



AIA - 193 Å



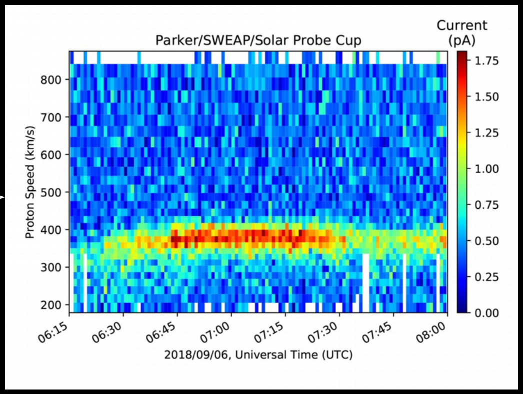
AIA - 211 Å



AIA - 304 Å

Parker Solar Probe

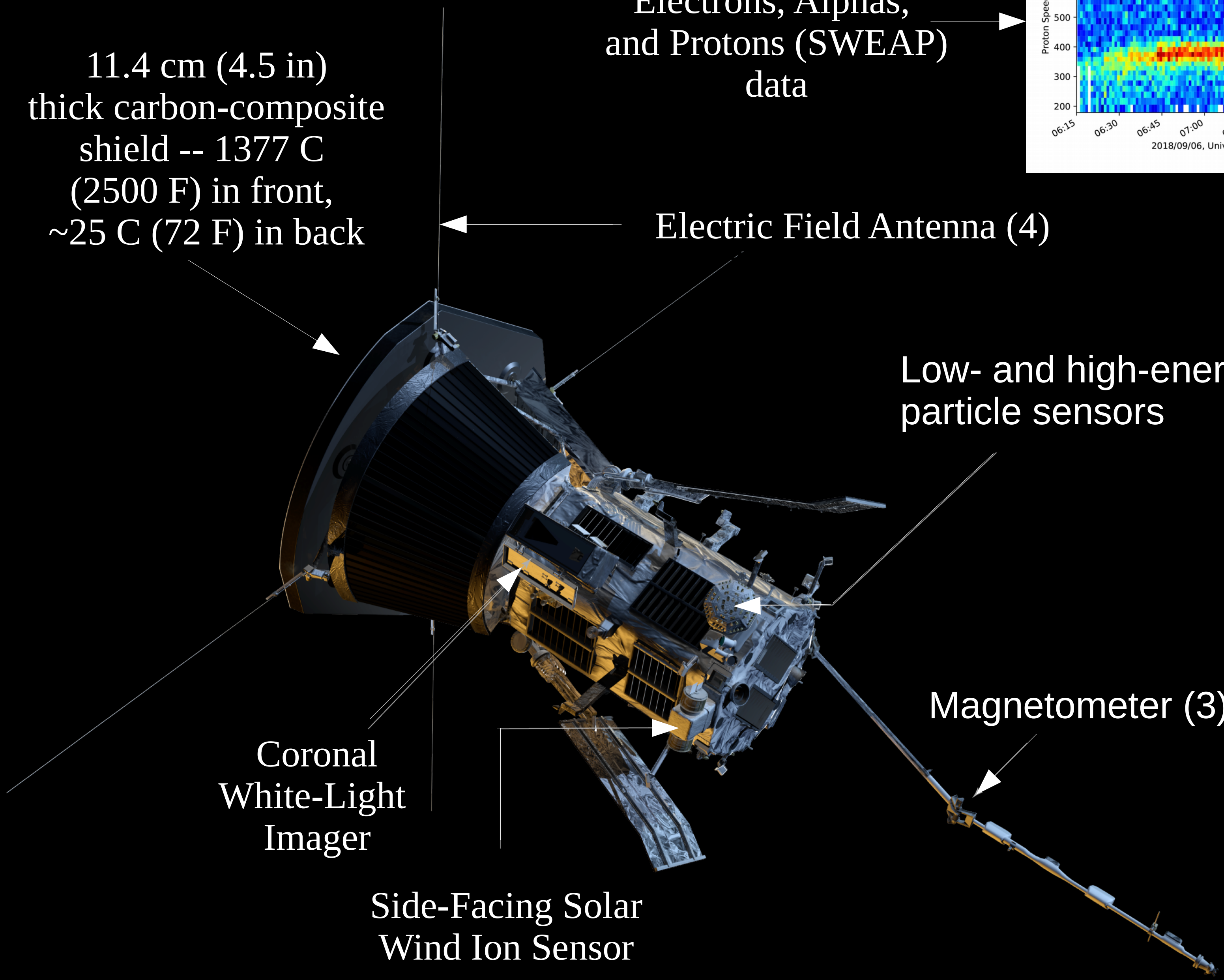
Solar Wind Electrons, Alphas, and Protons (SWEAP) data



11.4 cm (4.5 in) thick carbon-composite shield -- 1377 C (2500 F) in front, ~25 C (72 F) in back

Electric Field Antenna (4)

Low- and high-energy solar particle sensors



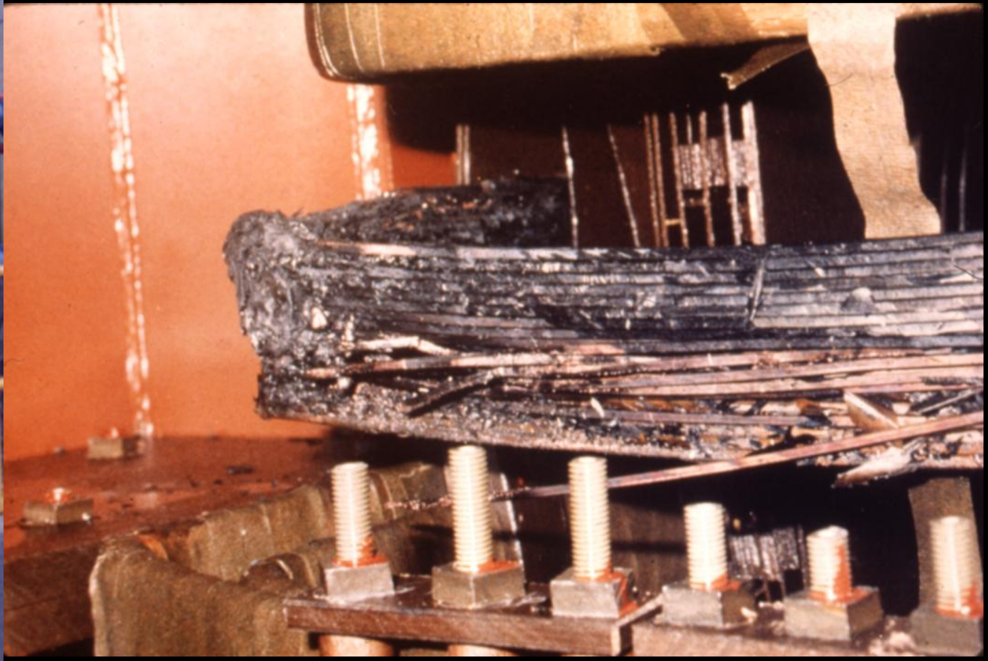
Magnetometer (3)

Coronal White-Light Imager

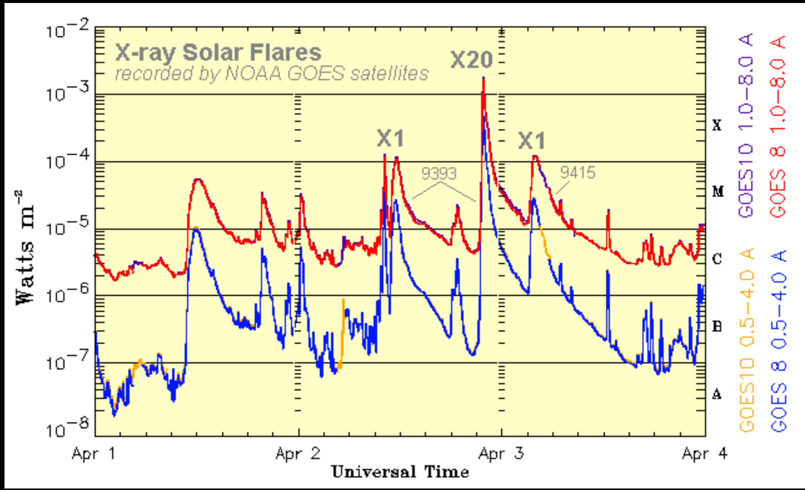
Side-Facing Solar Wind Ion Sensor

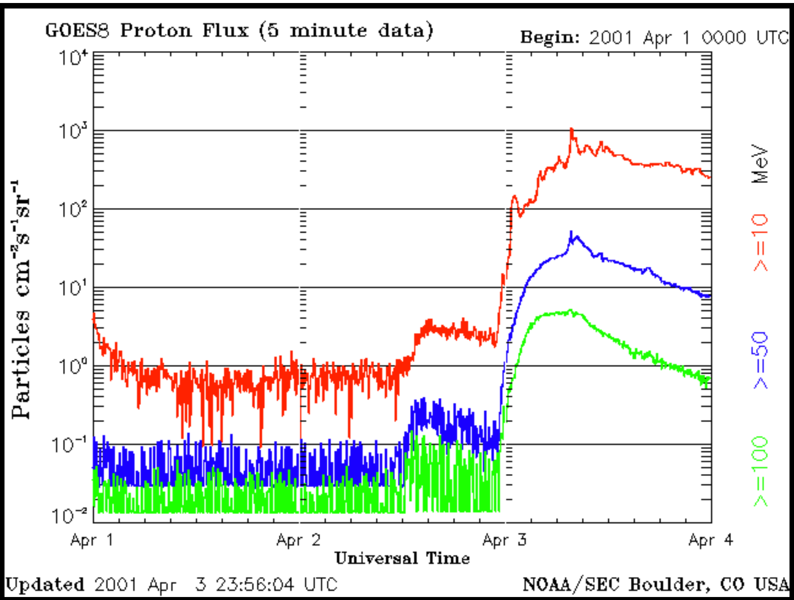
Why Do We Care?

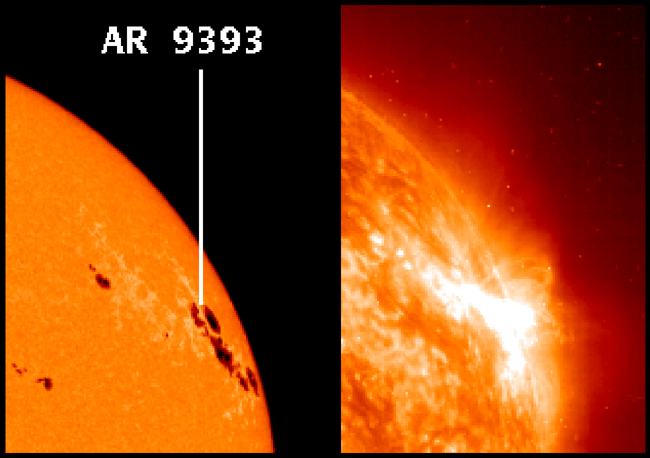
One phase of a 1200 MVA bank of three transformers, knocked out by a solar particle storm in 1989. The unit can cost up to $10 million and replacement can take up to one year. The large blue boxes house copper coils of wire. Note below, the result of the extra induced current.

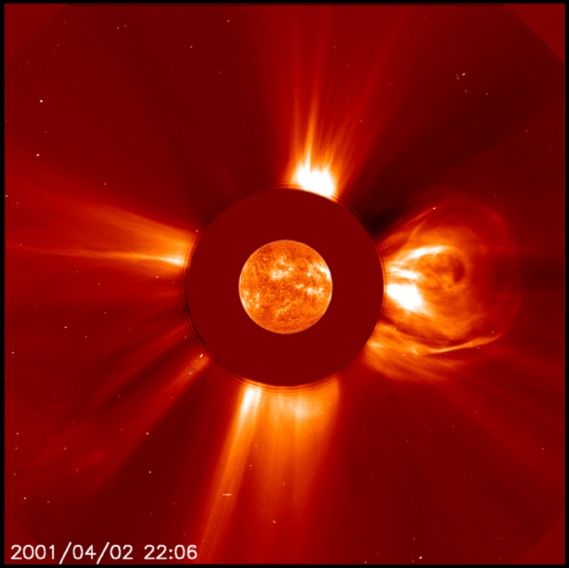


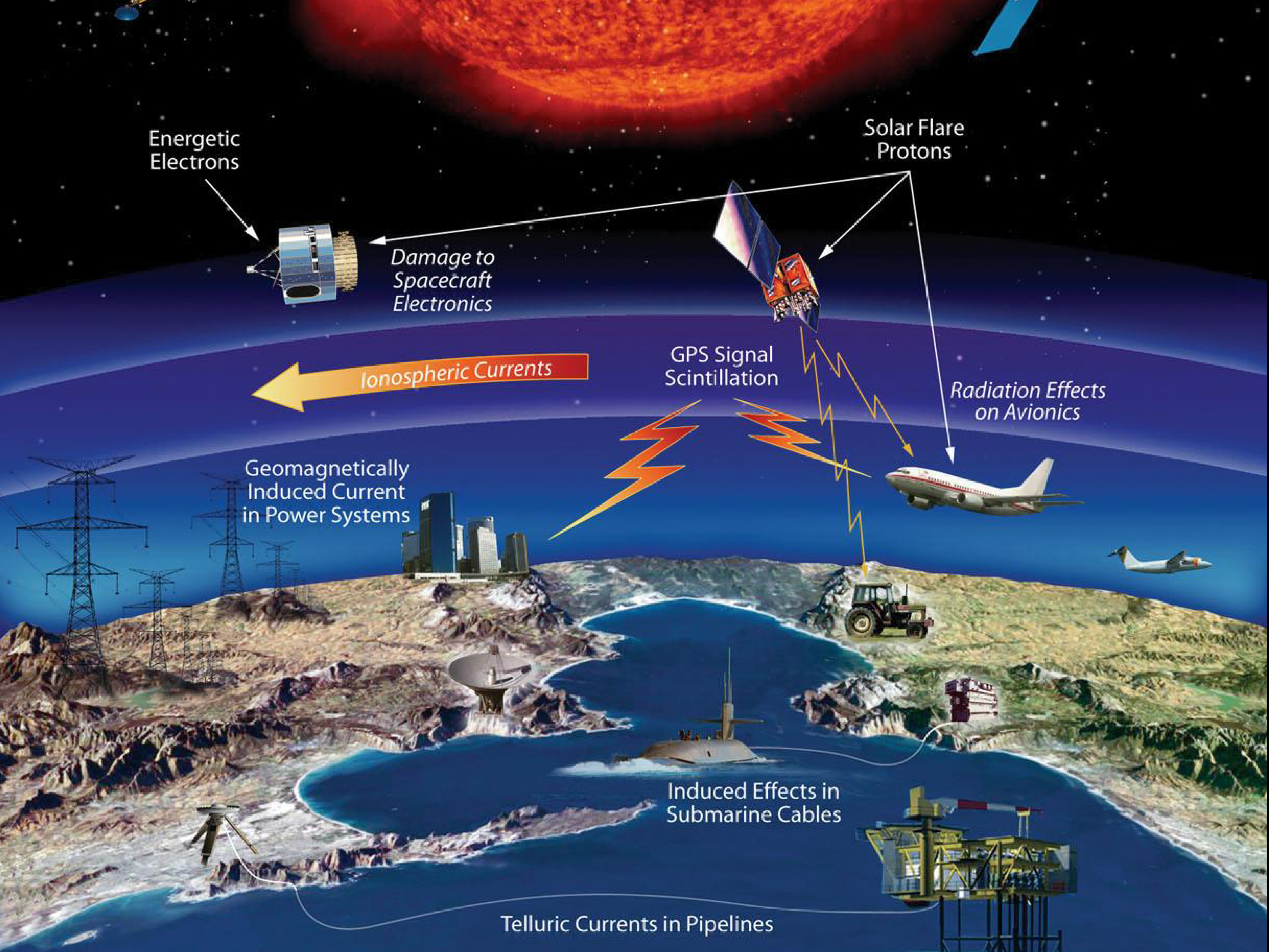
- At 21:51 UT, Monday 2 April 2001, active region 9393 unleashed a major solar flare reclassified as at least an X20 It appears to be the biggest flare on record, most likely bigger than the one on 16 August 1989 and definitely more powerful that the famous 6 March 1989 flare which was related to the disruption of the power grids in Canada.










Energetic
Electrons
Solar Flare
Protons
Damage to
Spacecraft
Electronics
GPS Signal
Scintillation
Ionospheric Currents
Radiation Effects
on Avionics
Geomagnetically
Induced Current
in Power Systems
Induced Effects in
Submarine Cables
Telluric Currents in Pipelines